SENIOR RESEARCH

Phys 482 Fall 2019

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Office Hours: M 3 – 4pm, T 11am – 12noon, W 2 – 3pm, R 9 – 10am, F 2 – 3 pm
Class Meetings: T 1:00 – 1:50pm, Wubben/Science 218

Overview

Physics is an evolving subject and research into phenomena and aspects of physics have been part of the discipline for centuries. Physics 482 offers you the opportunity to conduct research under the supervision of a faculty member. In this course, you will work on one physics-related problem or issue beyond that which you have encountered in your formal courses. At the outset, you probably will not how to solve the problem that you are investigating or whether a solution even exists. This uncertainty is almost always part of research. But you will the chance to plot your own course and make exciting discoveries and advances.

Course Structure

You will work under the supervision of one or more faculty members on a project of your choice. The only restrictions on the nature of the project are that it must fall within an area of physics, it should be within our capabilities to conduct safely at Colorado Mesa University and that your faculty supervisor should approve of it.

There will be a weekly "group meeting" of all students in the course. During this meeting you will describe progress on and discuss issues with your project. Additionally there are certain specific other tasks that you will be required to perform and report to me. These are listed below.

Expectations, Assignments and Grades

Your project must rely on concepts and techniques with a degree of difficulty and sophistication typical for 300 and 400 level courses in physics, mathematics or related disciplines. The complexity of the project should be comparable to that of multiple typical upper division physics homework problems and/or laboratory experiments. Your project should aim to synthesize material from at least two typical upper division courses in physics, mathematics, computer science, chemistry or a related discipline.

You are expected to work steadily at a rate consistent with a one-hour credit course (at least 3 to 4 hours of work on the project per week). If your project is in **experimental physics** you are expected to have either constructed or configured a substantial piece of equipment or run an experiment, gathered and analyzed meaningful data. If your project is in **theoretical physics** you should have carried out substantial calculations or elaboration of theory. If your project is in **computational physics** you should have developed a substantial piece of code or generated and analyzed numerical data.

Most of your efforts in this course will be directed by the supervisor of your project. However, there are components with specific deadlines and work on these tasks must be reported to me by the deadline. These components depend on whether you will be initiating a new project this semester or not.

1. If **this is the first time you are taking Phys 482 or you are starting a different project from the previous semester** then the components are:

Deadline	**Component**
Weekly	Group meetings. Discuss progress on project.
26 August 2019	Select faculty supervisor and project topic. If this is the second semester of your project, you must supply a *specific question or issue* that your project will address.
2 September 2019	Provide at least one source (texts, journal articles, etc, ...) that address the issue or a closely related issue covered by your project.
16 September 2019	Describe what each of your source/s has/have demonstrated in relation to the issue covered by your project. Your description must include the question/s addressed in the source, a summary of the the methods used to answer the question and a summary of the results. Describe how your project will extend these.
14 October 2019	Progress report of length at least three pages.
22 November 2019	First draft of final report.
6 December 2019	Final draft of final report.

The grade will be based on:

(a) Weekly "group meetings." Each meeting will carry a score of 4 points. You will receive 4 points for each meeting that you attend and in which present progress commensurate with at least three hours of work on your project since the last meeting. You will receive 1 point if you attend but have no progress to report. You will receive 0 points if you do not attend. The points for all meetings will be totaled and scaled to form 10% of the course grade.

(b) The three preliminary tasks, due in August and September, listed above.

(c) The level, complexity and scientific correctness of the project together with the effort involved.

(d) A progress report graded according to the rubric provided below.

(e) A final report graded according to the rubric provided below.

The grade will be distributed according to

Component	**Grade Fraction**
Meetings	10%
Project topic	2%
Literature sources	2%
Literature summary	6%
Complexity/effort	30%
Progress Report	20%
Final Report first draft	10%
Final Report final draft	20%

2. If **this is the second time you are taking Phys 482 and you are continuing a project from a previous semester** then the components are:

Deadline	**Component**
Weekly	Group meetings. Discuss progress on project.
14 October 2019	Progress report of length at least three pages.
22 November 2019	First draft of final report.
6 December 2019	Final draft of final report.

   (a) Weekly "group meetings." Each meeting will carry a score of 4 points. You will receive 4 points for each meeting that you attend and in which present progress on your project since the last meeting. You will receive 1 point if you attend but have no progress to report. You will receive 0 points if you do not attend. The points for all meetings will be totaled and scaled to form 10% of the course grade.

   (b) The level, complexity and scientific correctness of the project together with the effort involved.

   (c) A progress report graded according to the rubric provided below.

   (d) A presentation delivered at the CMU student showcase.

   (e) A final report graded according to the rubric provided below.

   The grade will be distributed according to

Component	**Grade Fraction**
Meetings	10%
Complexity/effort	30%
Progress Report	20%
Final Report first draft	12%
Final Report final draft	28%

   In order to be considered for full credit, the work done on the project must reflect substantial advances over the work completed in the first semester of the project. The effort, new results attained and additional writing must at least match those done in the first semester in order to replicate the grade for that semester; the grade for work of a lesser standard will be pro-rated accordingly.

Grading Procedures

Regardless of whether this is the first or second time that you are taking the course, letter grades will be assigned based on the total numerical grade for the course. The following letter grades are guaranteed; It is possible that the cut-offs can be shifted downward.

90% – 100%	A
80% – 89%	B
65% – 79%	C
50% – 64%	D

Grading rubrics for various components of the course are provided on the following pages.

Grading Rubrics

1. **Complexity and Effort:** The grade for the complexity and effort portion of the course is assessed according to the following rubric. For the second semester of the project the effort is based on work done in that semester only. The relative weight of each component toward the overall 30% is indicated.

Score	0	1	2	3	4
Conceptual Level (20%)	Does not use concepts or experimental techniques from physics.	The concepts and techniques in the work all appear in typical 100 level physics courses.	The concepts and techniques in the work all appear in typical 200 or lower level physics courses.	Some concepts and techniques in the work appear in typical 300 or higher level physics courses but these are not central to the main body of the work. The remaining concepts and techniques in the work all appear in typical 200 or lower level physics courses.	The work relies on concepts and techniques typical of 300 or higher level physics courses.
Complexity (20%)	Comparable to less than one 100-level physics HW assignment problem.	Comparable to a single 100 or 200-level physics HW assignment problem.	Comparable to a single 300-level physics HW assignment problems or a single 200/300 level physics experiment.	Comparable to synthesizing three or more 300-level physics HW assignment problems and/or 200/300 level lab exercises. Work relies on ideas/techniques from only one 300-level undergraduate course (any discipline).	Comparable to synthesizing three or more 300-level physics HW assignment problems and/or 200/300 level lab exercises. Work relies on ideas/techniques from more than one 300-level undergraduate course (any discipline).
Scientific Correctness (30%)	None present.	Some or all of the physical concepts, mathematics, experimental techniques or data analysis are incorrect or unclear. Could not be revised and still retain the main findings of the work.	Some or all of the physical concepts, mathematics, experimental techniques or data analysis are incorrect or unclear. Could be revised and still retain the main findings of the work.	All use of key physical concepts, mathematics, experimental techniques or data analysis is correct/clear. Minor errors or lack of clarity, which do not undermine the central findings of the project, are widespread throughout the report.	All use of key physical concepts, mathematics, experimental procedures or data analysis is correct/clear. Minor errors, that do not undermine the central findings of the project, are permissible.
Effort (30%)	None	Some but less than 1/9 of upper division course.	Between 1/9 and 2/9 of upper division course.	Between 2/9 and 3/9 of upper division course.	Same as 3/9 = 1/3 of upper division course.

2. **Progress Report:**

   The progress report should be written in the style of a scientific journal article, although there will be some latitude with regard to formatting and the details of the description of the science behind the project. Examples of journal articles can be found in the *American Journal of Physics* or the *Physical Review* journal series. The following components will be evaluated:

   (a) **Introduction:** The introduction must contain a description of the question or issue that the project addresses, why it is interesting, what other investigations have found about this question and how your project will address the question.

   (b) **Major ideas:** Every scientific work is built on a small number of major ideas; if one of these is missing then the report will make no sense or be unconvincing to an outside reader. In the report, the major ideas must appear in a logical order and each must be introduced with a brief motivation.

   (c) **Minor ideas:** Within and amongst the major ideas that sustain the work, there will be numerous smaller ideas and details; if one of these is missing an outside reader will be able to understand the general idea of the work but may have to fill in some details to render it convincing. In the report, such minor ideas must appear in a logical order and each must be connected to its predecessor or else introduced with a brief motivation.

   (d) **Writing:** Writing should be done in a professional style with a neutral tone. Colloquial or conversational style of language must not appear in the report. Repeated statements and other forms of verbosity must not appear in the report.

   The progress report will be assessed according to the following rubric (for second semester continuation, it will reflect new material since the first semester final report). Note that 1/6 of an entire upper division course is comparable to 2.5 weeks of a typical 3 credit hour course.

Progress Report Rubric

Score	0	1	2	3	4
Conceptual Level (10%)	Same as complexity/effort rubric				
Complexity (10%)	Same as complexity/effort rubric				
Scientific Correctness (15%)	Same as complexity/effort rubric				
Progress and Effort (30%)	None	Some but less than 1/18 of an entire upper division course.	Between 1/18 and 2/18 of an entire upper upper division course.	Between 2/18 and 3/18 of an entire upper upper division course.	Same as $3/18 = 1/6$ of an entire upper upper division course.
Introduction (5%)	None	Misses all of: a clear description of the issue under investigation, why it is interesting, what prior investigations have found and what this work offers.	Misses two of: a clear description of the issue under investigation, why it is interesting, what prior investigations have found and what this work offers.	Misses one of: a clear description of the issue under investigation, why it is interesting, what prior investigations have found and what this work offers.	Includes all of: a clear description of the issue under investigation, why it is interesting, what prior investigations have found and what this work offers.
Order of Major Ideas (15%)	The number of major ideas that need to be moved, added or removed is more than 75% total number of major ideas.	The number of major ideas that need to be moved, added or removed is between 75% and 50% of the total number of major ideas.	The number of major ideas that need to be moved, added or removed is between one and 50% of the total number of major ideas.	Only one major idea needs to be moved, added or removed.	No major ideas need to be rearranged.
Order of Minor Ideas (10%)	More than 75% of the minor ideas need to be moved, added or removed.	Between 50% and 75% of the minor ideas need to be moved, added, removed or appear without any motivation.	Between 25% and 50% of the minor ideas need to be moved, added, removed or appear without any motivation.	Between 5% and 25% of the minor ideas need to be moved, added, removed or appear without any motivation.	Fewer than 5% of minor ideas need to be moved, added, removed or appear without any motivation.
Writing (5%)	Writing always displays stylistic issues such as use of colloquial language or verbosity.	Writing usually displays stylistic issues such as use of colloquial language or verbosity.	Writing often displays stylistic issues such as use of colloquial language or verbosity.	Writing sometimes displays stylistic issues such as use of colloquial language or verbosity.	Writing needs little modification.

3. **Final Report:**

   The first and final drafts of the final report will be assessed according to the following rubric, broken down into the following subcategories. Within each category, there are several subcategories and the relative weight of each toward the grade for either draft of the final report is indicated.

   (a) **Formatting:** The report must be written in the style of a scientific journal article. Examples can be found in the *American Journal of Physics* or the *Physical Review* journal series. The following components are essential:

      i. *Title, . . . :* The title must reflect the work accurately. An author name and affiliation are required.

      ii. *Abstract:* The abstract must briefly summarize the issue investigated, the means of investigation and the main findings of the work.

      iii. *Sections:* The report must be divided into sections that accurately delineate and reflect the main pieces of the work.

      iv. *References:* References must be cited within the text and listed at the end of the report using the style of one of the journals listed above.

      v. *Figures and tables:* Figures, diagrams, pictures and tables must be "floating," be numbered in order of appearance and captioned meaningfully. There must be at least one reference to each figure and table within the text.

   (b) **Scientific Content and Exposition:** The bulk of the grade for the final report considers whether the report clearly describes the work in a logical order. Considerations are:

      i. *Introduction:* The body of the report must begin with an introduction that briefly describes the issue or question investigated. The introduction must describe the broader context of the work, why the issue is interesting or important and what other investigations into the issue have found.

      ii. *Major ideas:* Every scientific work is built on a small number of major ideas; if one of these is missing then the report will make no sense or be unconvincing to an outside reader. In the report, the major ideas must appear in a logical order and each must be introduced with a brief motivation.

      iii. *Minor ideas:* Within and amongst the major ideas that sustain the work, there will be numerous smaller ideas and details; if one of these is missing an outside reader will be able to understand the general idea of the work but may have to fill in some details to render it convincing. In the report, such minor ideas must appear in a logical order and each must be connected to its predecessor or else introduced with a brief motivation.

      iv. *Scientific exposition and clarity:* The work will probably rely on features specific to scientific disciplines; these include mathematical derivations, experimental details (e.g. circuit descriptions), information processing algorithms, and data analysis. These must be described clearly at a level appropriate for upper division level physics courses.

(c) **Writing:** A portion of the grade for the final report considers the quality of the writing and whether suggested revisions were done.

i. *Grammar, spelling, . . . :* The report must use standard English grammar, spelling, usage rules and punctuation.

ii. *Mathematical grammar:* Equations and mathematical entities must fit within the standard grammatical rules and must appear as part of a sentence (although they may be typeset on new lines).

iii. *Writing style:* Writing should be done in a professional style with a neutral tone. Colloquial or conversational style of language must not appear in the report. Repeated statements and other forms of verbosity must not appear in the report.

iv. *Revisions:* Revisions will be suggested after each version of the report is submitted; these must be addressed.

Final Report Rubric: Formatting Category

Score	0	1	2	3	4
Title, author, affiliation (1% 1^{st}, 1% fin)	None	No title present. Other information supplied.	Two of title, author, or affiliation is missing.	One of title, author, or affiliation is missing or the language is incorrect.	All appears with appropriate language and information.
Abstract (3% 1^{st}, 6% fin)	None present.	Abstract exists but fails to clearly describe any of: primary issue, method of investigation, and results.	Abstract clearly describes only one of: primary issue, method of investigation, and results.	Abstract clearly describes only two of: primary issue, method of investigation, and results or it contains excessive information.	Abstract clearly describes all of: primary issue, method of investigation, and results. Abstract does not contain excessive information.
Sections (4% 1^{st}, 4% fin)	Not delineated.	Number of missing or excessive sections is between 50% and 100% of total number of sections (for correctly section document).	Number of missing or excessive sections is between 25% and 50% of total number of sections (for correctly section document).	Number of missing or excessive sections is less than 25% of total number of sections (for correctly section document).	Sectioning is complete with no appearance of unnecessary sections or no need for additional sections. Section titles are clear and appropriate.
References (1% 1^{st}, 3% fin)	None present.	Between 75% and 100% of the author, journal/text, page, year in all references are absent.	Between 50% and 75% of the author, journal/text, page, year in all references are absent.	Between 25% and 50% of the author, journal/text, page, year in all references are absent.	Less than 25% of the author, journal/text, page, year in all references are absent.
Figures and Tables (if applicable) (1% 1^{st}, 1% fin)	Less than 20% of figures and tables have captions and a text reference.	Between 20% and 40% of figures and tables have meaningful captions and a text reference. Or most tabular material appears in the text.	Between 40% and 60% of figures and tables have meaningful captions and a text reference. Or most tabular material appears in the text.	Between 60% and 80% of figures and tables have meaningful captions and a text reference. Or some tabular material appears in the text.	At least 80% of figures and tables have meaningful captions and a text reference. No tabular material appears in the text.

Final Report Rubric: Scientific Content and Exposition Category

Major ideas refer to the major points of the work. Minor ideas refer to subideas within these major ideas. Scientific details refers to uncertainties, significant figures, graph axes labels, etc . . . .

Score	0	1	2	3	4
Introduction (5% 1st, 5% fin)	None present.	Misses at least two of: a clear description of the issue under investigation, why it is interesting and prior investigations have found.	Misses one of: a clear description of the issue under investigation, why it is interesting and prior investigations have found.	Includes all of: a clear description of the issue under investigation, why it is interesting and prior investigations have found. There is some superfluous content, or ordering is inappropriate.	Includes all of: a clear description of the issue under investigation, why it is interesting and prior investigations have found. There is no superfluous content.
Order of Major Ideas (30% 1st, 13% fin)	More than 75% of the major ideas need to be moved, added or removed.	Between 50% and 75% of the major ideas need to be moved, added, removed or appear without any motivation.	Between one and 50% of the major ideas need to be moved, added, removed or appear without any motivation.	Only one of the major ideas needs to be moved, added, removed or appears without any motivation.	No major ideas need to be rearranged.
Order of Minor Ideas (20% 1st, 12% fin)	More than 75% of the minor ideas need to be moved, added or removed.	Between 50% and 75% of the minor ideas need to be moved, added, removed or appear without any motivation.	Between 25% and 50% of the minor ideas need to be moved, added, removed or appear without any motivation.	Between 5% and 25% of the minor ideas need to be moved, added, removed or appear without any motivation.	Fewer than 5% of minor ideas need to be moved, added, removed or appear without any motivation.
Scientific Exposition and Clarity (10% 1st, 15% fin)	More than 75% of the crucial scientific concepts or techniques are unclear.	Between 50% and 75% of the crucial scientific concepts or techniques are unclear.	Between 25% and 50% of the crucial scientific concepts or techniques are unclear.	Less than 25% of the crucial scientific concepts or techniques are unclear	All scientific concepts or techniques are explained clearly.
Scientific Details (15% 1st, 14% fin)	More than 75% are incorrect.	Between 75% and 20% are incorrect.	Between 50% and 20% are incorrect.	Between 20% and 5% are incorrect.	Fewer than 5% are incorrect.

Final Report Rubric: Writing Category

Score	0	1	2	3	4
Conventional grammar, spelling and punctuation (4% 1st, 8% fin)	More than 50% of sentences require correction.	Between 50% and 10% of sentences require correction.	Between 10% and 5% of sentences require correction.	Between 5% and 1% of sentences require correction.	Less than 1% of sentences require correction.
Mathematical grammar (1% 1st, 1% fin)	More than 75% of the mathematics requires grammatical correction.	Between 75% and 50% of the mathematics requires grammatical correction.	Between 50% and 25% of the mathematics requires grammatical correction.	Between 25% and 5% of the mathematics requires grammatical correction.	Less than 5% of the mathematics requires grammatical correction.
Writing style (5% 1st, 7% fin)	Writing always displays stylistic issues such as use of colloquial language or verbosity.	Writing usually displays stylistic issues such as use of colloquial language or verbosity.	Writing often displays stylistic issues such as use of colloquial language or verbosity.	Writing sometimes displays stylistic issues such as use of colloquial language or verbosity.	Writing needs little modification.
Revisions (0% 1st, 10% fin)	Less than 25% of revisions have been addressed.	Between 25% and 50% of revisions have been addressed.	Between 50% and 75% of revisions have been addressed.	Between 75% and 100% of revisions have been addressed.	All revisions have been addressed.

Student Learning Outcomes

A student who has taken this course will have demonstrated the ability to:

1. Execute a program of research on a new issue in physics.
2. Apply concepts, techniques and knowledge from various areas of physics and related fields to a significant and complex issue in physics.
3. Produce a report, in the style of a scientific journal article, on a research topic.

This course contributes to the fulfillment the following program learning objective for the BS in Physics degree. A student will have demonstrated the ability to:

1. Execute a project which addresses a significant and complex issue in physics. This project will integrate knowledge and techniques from different areas of physics.

Policies

1. **Helpful Resources:** The Tutorial Learning Center (TLC) is a *free* academic service for all CMU students. Tutors are available in Houston Hall 113 on a walk-in basis for many courses. More information is available at www.coloradomesa.edu/tutoring or 248-1392.

   In coordination with Educational Access Services, reasonable accommodations will be provided for qualified students with disabilities. Please meet with the instructor the first week of class to make arrangements. Nancy Conklin, the Coordinator of Educational Access Services, can be contacted at 248-1826, or in person at Houston Hall 108.

2. **Withdrawals:** There are several ways to drop this course. The deadline for dropping without penalty is **9 September 2019.** Please consult the CMU academic calendar and catalog for more details about adding and dropping courses.

3. **Attendance:** Attendance policies are described in the CMU catalog. You are expected to attend all the class meetings. In case of illness or other emergencies you must be able to produce the appropriate documentation. There are other circumstances under which you can be excused but you must discuss these with me in advance. If you miss a class or lab for a valid reason, turn in any assignments due before the start of the next class. Assignments turned in beyond your return to class will not be accepted.

4. **Academic integrity:** You are expected to present your own work in assignments, exams and quizzes. Fabrication of data, plagiarism, and copying from anyone else, particularly in closed book exams, are serious violation of academic norms. CMU has extensive policies on these matters and penalties for infringement can be severe. For more details, consult the academic integrity policies in the CMU catalog.